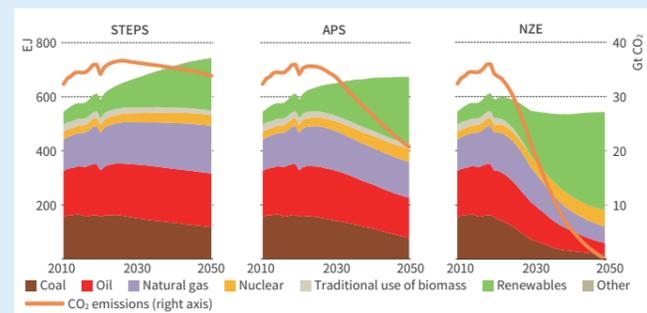


Special Feature Creating Business Opportunities / Solving Customer Challenges in the Energy Transition

International Energy Agency (IEA) Executive Director Fatih Birol says that to reach net zero emissions by 2050, we need more than triple investment in clean energy projects and infrastructure over the next ten years.

Total Primary Energy Supply by Fuel and Scenario



STEPS: Stated Policies Scenario, which reflects current policy settings and is announced by governments around the world.
 APS: Announced Pledges Scenario, which assumes all climate commitments made by governments around the world, including those not yet implemented.
 NZE: Net Zero Emissions by 2050 Scenario
 Source: IEA World Energy Outlook 2021

• STEPS Scenario: almost all of the net growth in energy demand to 2050 is met by low-emissions sources, but annual emissions remain unchanged, with global average temperatures continuing to rise to reach 2.6°C above pre-industrial levels in 2100.
 • APS Scenario: Demand for fossil fuels peaks by 2025, and global CO₂ emissions fall by 40% by 2050. All sectors see a decline, with the electricity sector delivering by far the largest. The global average temperature rise in 2100 is held at around 2.1°C. Even under this scenario, it would be difficult to achieve net zero CO₂ emissions or the Paris Agreement.

Further reductions in CO₂ emissions over the next ten years and beyond 2030 are needed to close the gap between the current commitments and the 1.5 °C scenario

Source: JETRO Biz News (October 14, 2021)

Yokogawa's Initiatives for Solution Business

Customers in the energy-related industry are addressing the energy transition to realize a carbon-neutral society while fulfilling their product supply responsibilities to the market. As a trusted partner, Yokogawa provides solutions to meet that challenge together with our customers.

Use of Fossil Fuels Promotion of Efficient

We successfully implemented proof-of-concept (PoC) of the Rigorous Integrated Optimization System "RIOS," which maximizes profits by optimizing production throughout the oil refining supply chain.

RIOS is a comprehensive digital twin solution from YOKOGAWA and KBC to optimize the entire oil refining production process by simulating fluctuating demand and crude oil prices. This enables us to maximize our customers' profits and is one of the challenges for Yokogawa in establishing a recurring business model of performance-based compensation.

RIOS Rigorous integrated optimization system

- Integrated Yokogawa + KBC digital twin solution for simulation of IN(Procurement) - OUT(Deriver) process
- Maximization of profits by optimizing production throughout the oil refining supply chain in response to shifts in demand and crude oil market prices

※IA2IA: Industrial Automation to Industrial Autonomy / PoC: Proof of Concept

Low-Emission Energy Natural gas including LNG

In pursuit of economic growth and energy transition, natural gas is becoming increasingly important, with the European Union approving a policy (July 2022) that positions natural gas as a green energy source.

Leveraging Yokogawa's many references throughout the entire LNG value chain, including Liquefaction, LNG Carrier, Regasification, Storage, and Delivery, we will provide both the CAPEX business and the OPEX business with solutions for improving productivity, safety, and asset monitoring.

YOKOGAWA Experiences

Liquefaction trains are controlled by Yokogawa (76 Trains)
 LNG Carriers constructed using Yokogawa LNG controls (91 Vessels)
 Regasification plants are controlled by Yokogawa (54 Terminals)

Renewable Energy Strengthen initiatives related to the hydrogen supply chain

Toward the coming hydrogen society, we have established an in-house industry-wide project team to identify Yokogawa's core values in the hydrogen supply chain, including hydrogen production and delivery.



Special Feature Yokogawa's Renewable Energy Business



Our energy-related customers are accelerating their transformation into comprehensive energy companies and expanding their investments in low-carbon businesses. Yokogawa is also accelerating our energy transition.

Go Iwata Energy & Sustainability Business Headquarters
 Power & Water Business Center

Yokogawa's Focus on Renewable Energy

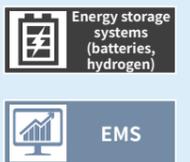


Global demand for solar and wind power is expected to increase further. Yokogawa has a strong track record in biomass, geothermal, and CSP power projects, and these are fields where our industrial automation products and accumulated knowledge are assets. To expand our business in the high-growth solar and wind power fields, we will widen our focus beyond the current range of IA solutions to cover the management of business operations, including asset and energy management, data-based planning, and asset lifecycle optimization.

*1 WTE: Waste to energy

Yokogawa's Contribution Field

In renewable energy sectors such as solar and wind, the output varies greatly depending on the time of day, weather conditions, and seasons, so the ability to accurately predict and manage these factors is essential. In terms of capacity, renewable energy facilities are much smaller than thermal and nuclear power plants, so a larger number of these facilities is required. It is also important to control supply and demand. To ensure a stable supply of power from such facilities, we provide not only power generation products and solutions but also energy management systems (EMS*), battery energy storage systems (BESS), and hydrogen energy storage systems.



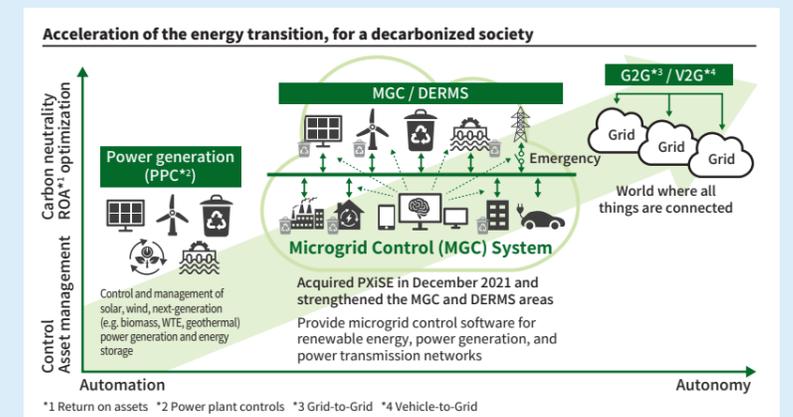
*2 VRE: Variable renewable energy *3 EMS: Energy Management System

Partnerships to Grow Our Business

Renewable energy covers a wide variety of fields, so we expand our business by tapping the knowledge of outside experts and incorporating that into the solutions we provide.

As more power generation facilities and energy storage systems are installed in offices and homes, conventional unidirectional energy supply will become increasingly bidirectional. To roll out distributed energy resource management systems (DERMS) and microgrid control (MGC) systems that can manage and control large numbers of facilities and intricately interconnected power grids, Yokogawa acquired PXISE Energy Solutions, a company with related technologies, in December 2021.

Expanding the renewable energy market will accelerate the move to "system of systems," where multiple discrete facilities and systems are inter-connected. By entering the MGC and DERMS markets, Yokogawa will position itself to make a greater contribution to an increasingly interconnected world.



*1 Return on assets *2 Power plant controls *3 Grid-to-Grid *4 Vehicle-to-Grid

In a World First, Using AI to Autonomously Control a Chemical Plant for 35 Consecutive Days

- A Great Step Toward Realizing Customers' Industrial Autonomy -

ENEOS Materials Corporation (formerly JSR Corporation's elastomer business unit) and Yokogawa have succeeded in using reinforcement learning AI to autonomously control a process at an ENEOS Materials chemical plant for 35 days, a world first.

Hiroaki Kanokogi

President & CEO, Yokogawa Digital Corporation
DX-Platform Center, Digital Solutions Headquarters, Yokogawa Electric Corporation



What Yokogawa Achieved

This test confirmed that reinforcement learning AI can be safely applied in an actual plant, and demonstrated that this technology can control operations that have been beyond the capabilities of existing control methods and have up to now necessitated the manual operation of control valves based on the judgments of plant personnel. The initiative described here was selected for the 2020 Projects for the Promotion of Advanced Industrial Safety subsidy program of the Japanese Ministry of Economy, Trade and Industry.

In this field test, the AI solution successfully dealt with the complex conditions needed to ensure product quality and maintain liquids in the distillation column at an appropriate level while making maximum possible use of waste heat as a heat source. In so doing it stabilized quality, achieved high yield*¹, and saved energy. While rain, snow, and other weather conditions were significant factors that could disrupt the control state by causing sudden changes in the atmospheric temperature, the products that were produced met rigorous standards and have since been shipped. Furthermore, as only good quality products were created, fuel, labor, time, and other losses that occur when off-spec products are produced were all eliminated.

*1 Yield: The volume of the target substance that is actually obtained from raw materials through the refinement process

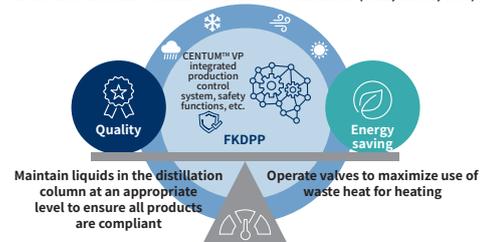


Distillation columns at the ENEOS Materials corporation chemical plant

AI "FKDPP" at Yokogawa and Nara Institute of Science and Technology

The AI used in this control experiment, the Factorial Kernel Dynamic Policy Programming (FKDPP) protocol, was jointly developed by Yokogawa and the Nara Institute of Science and Technology (NAIST) in 2018. It can be used in areas where automation previously was not possible with conventional control methods and its strengths include being able to deal with conflicting targets such as the need for both high quality and energy savings.

Separate substances with similar boiling points and achieve high quality and energy savings while into account sudden external disturbances (rain, snow, etc.)



Toward Realizing Customers' Industrial Autonomy

The present reality is that many aspects of plant control involve complexities that require the knowhow of skilled operators. A big challenge is how to make the transition to autonomous control while maintaining a high level of safety, and the results of this successful field test provide clues for a solution.

Yokogawa will continue these efforts with its partners to co-create solutions that benefit its customers.

Results of the field test			
Autonomous control Areas that previously couldn't be controlled with PID control and APC were autonomously controlled by reinforcement learning-based AI (the FKDPP algorithm)	35 days Managed and controlled with CENTUM™ VP integrated production control system	Safe operation and improved productivity Simultaneously achieved safe operation and improved productivity, with stable quality, high yield, and energy saving	Reduced cost and time loss Only high quality products were produced, so losses in time (the form of fuel, labor costs, time, etc.) that occur due to production of off-spec products were eliminated

Yokogawa Digital Corporation Established to Support DX in Manufacturing

In July 2022, Yokogawa Digital Corporation was established to support DX in manufacturing to achieve global total optimization, providing integrated services from management consulting to cloud system implementation, operation and maintenance.

With the COVID-19 pandemic, responding to supply chain issues, contributing to SDGs, and practicing ESG management have all become necessary, and companies must optimize their entire business activities from management to the field, including the supply chain to enhance competitiveness and contribute to the realization of a sustainable society. To achieve this, DX, including the use of AI, is essential. Yokogawa will use its knowledge and know-how in both the OT and IT fields to support its customers' DX efforts, including the practical application of advanced technologies such as the examples above, and will work to realize integrated global management of their entire businesses.